Sova, Oleg; Zhuravskyi, Yurii; Shyshatskyi, Andrii et al.

Article

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Oleg Sova,
Yurii Zhuravskyi,
Andrii Shyshatskyi,
Oleksandr Zhuk,
Taras Hurskyi,
Oleksii Nalapko,
Roman Vozniak,
Serhiy Hatsenko,
Anna Lyashenko,
Oksana Havryliuk

DEVELOPMENT OF FORCE DISTRIBUTION METHODOLOGY AND MEANS OF COMMUNICATION FOR THE GROUPING OF TROOPS (FORCES) IN OPERATIONS

The most characteristic features of the construction of communication systems of groups of troops (forces) during the conduct of hostilities (operations) are a high degree of a priori uncertainty regarding the operational situation and a small amount of initial data for communication planning. In such conditions, it is important to correctly choose the apparatus for evaluating the made management decisions, which will allow the officials of the bodies (points) of the control system of the communication system of the groups of troops (forces) to be confident in the decisions being made. That's why the issue of increasing the efficiency of the distribution of forces and devices of communication of groups of troops (forces) in the course of operations is an important issue. The object of the research is the communication system of the group of troops (forces). The subject of the study is the effectiveness of the communication system of the group of troops (forces) in accordance with the purpose of the operation. In the research, the method for the distribution of forces and devices of communication of groupings of troops (forces) in operations was developed. The novelty of the proposed method consists in taking into account the type of uncertainty regarding the operational situation in the operational space. As well as taking into account the number of members of the group (users of communication services) of troops (forces) in operations. Also, the novelty of the developed method consists in taking into account the duration of the operation (fighting) and the calculation of the labor costs necessary to meet the needs of the communication services of groups of troops (forces) while planning measures for the distribution and use of forces and radio communication devices. The specified method is proposed to be implemented:

– in planning documents during planning of the deployment and operation of forces and radio communication devices;

– in the software, during operational management of the communication system of troop groups.

Keywords: *forces and devices of communication, radio-electronic situation, grouping of troops (forces), operational management.*

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1. Introduction

The most characteristic features of the construction of special purpose communication systems of groups of troops (forces) during the conduct of hostilities (operations) are a high degree of a priori uncertainty regarding the operational situation and a small amount of initial data for communication planning.

In such conditions, it is important to correctly choose the apparatus for evaluating the made management decisions, which will allow the officials of the headquarters of the control system of the communication system of the groups of troops (forces) to be confident in the decisions being made [1–3].

Making a decision to build a communication system of any level during combat operations, as a rule, includes determining the purpose of its operation, choosing indicators and substantiating evaluation criteria, synthesis of alternative structures and the search for a rational option for the deployment of the communication system [4–7].

As the experience of communication organization in operations (during hostilities) shows, the decision regarding

the order of communication organization, involvement of forces and devices necessary to meet the needs of communication services indicates [8–10]:

– the need to have a mathematical apparatus that will allow taking into account the volume of operational tasks for the organization of communication of groups of troops (forces);

– taking into account the numerical composition of the group (consumers of communication services) of groups of troops (forces);

– the duration of the operation (conduct of hostilities) and the labor costs necessary to meet the needs of communication services of groups of troops (forces).

Taking into account the above, *the aim of the research* is to develop a method for the distribution of forces and devices of communication of troop groupings (forces) in operations.

The object of the research is the communication system of a group of troops (forces).

The subject of the research is the effectiveness of the communication system of the group of troops (forces) in accordance with the purpose of the operation.

2. Research methodology

In the course of the conducted research, classical methods of analysis were used to solve the problem of analyzing the conditions and factors affecting the communication system of a group of troops (forces), as well as synthesis for making managerial decisions on the management of the communication system of a group of troops (forces).

3. Research results and discussion

3.1. Development of methods of distribution of forces and devices of communication of groups of troops (forces) in operations. The method of distribution of forces and devices of communication of groups of troops (forces) in operations consists of the following sequence of actions (Fig. 1).

1. *Input of output data*. At this stage, the initial data for communication planning is determined.

2. *Determination of the type of uncertainty about the situation state*. At this stage, the type of uncertainty about the state of the operational situation is determined: complete uncertainty, partial uncertainty and full awareness.

3. *Determination of a non-offensive composition of forces and devices of communication*. At this stage, the necessary number of forces and devices of communication necessary for the organization of communication is determined.

4. *Solving direct and reverse problems of distribution of forces and devices of communication*.

The tasks of optimal distribution of forces and devices of communication for the tasks of the operation assume the presence of the following attributes of the working data set:

– *AS* is the «volume» (as labor intensity) of tasks related to the organization of communication of a group of troops (forces) for the use of forces and devices of communication;

– *NS* is the numerical composition of forces (calculation units of forces are the forces and devices of communication), which perform the task of organizing communication for users of communication services;

– *TS* is the operation duration (time units);

– *RS* are the labor costs of forces for the execution of communication organization tasks (labor forces)×(unit of time);

– *Y* is a plan for the distribution of forces and devices of communication for tasks related to the organization of communication.

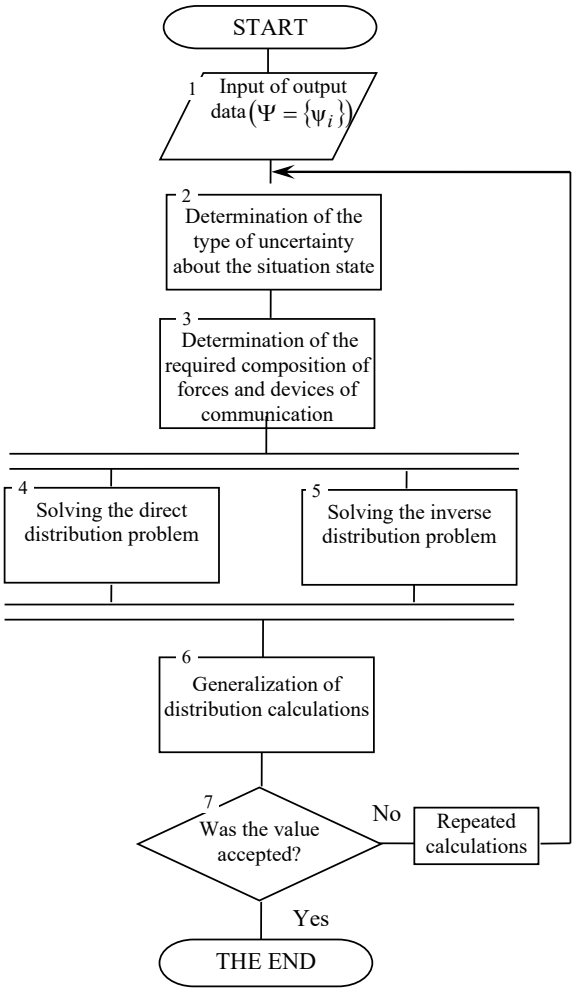

Fig. 1. Algorithm for implementation of the method of distribution of forces and devices of communication of groupings of troops (forces) in operations

The general formal statement of the problems of the direct problem of the distribution of forces and devices of communication of groupings of troops (forces) in operations according to the criterion (suitability of solutions) (optimality of solutions):

$$\forall Y, Y \subset \{Y\}_{dir} : NS(Y) \le NS^{ass};$$
$$\exists Y^o, Y^o \subset \{Y\}_{dir} : TS(Y^o) = \min_{\{Y\}_{dir}} TS(Y). \quad (1)$$

While solving the inverse problem according to the criterion (suitability of solutions) (optimality of the solution):

$$\forall Y, Y \subset \{Y\}_{back} : TS(Y) \le TS^{ass};$$
$$\exists Y^o, Y^o \subset \{Y\}_{back} : NS(Y^o) = \min_{\{Y\}_{back}} NS(Y). \quad (2)$$

The effectiveness of the distribution of forces and devices of communication in group operations while solving a direct problem is written in the following form:

$$ES(Y^o) = AS(Y^o) / RS(Y^o) = AS^{nes} / \min_{\{Y\}_{direct}} RS(Y) =$$
$$= AS^{nes} / \{NS^{ass} \cdot \min_{\{Y\}^{direct}} TS(Y)\} = \max_{\{Y\}_{direct}} ES(Y). \quad (3)$$

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The effectiveness of the distribution of forces and devices of communication in group operations while solving the inverse problem is written in the following form:

$$ES(Y^o) = AS(Y^o) / RS(Y^o) = AS^{nes} / \min_{\{Y\}_{back}} RS(Y) =$$
$$= AS^{nes} / \{\min_{\{Y\}^{back}} NS(Y) \cdot TS^{ass}\} = \max_{\{Y\}_{back}} ES(Y). \quad (4)$$

Let the «labor intensity» of the current communication organization tasks be known, the fulfillment of which must be ensured in the process of using forces in the operation:

$$A = \langle a_j,\ j = \overline{1,n} \rangle. \quad (5)$$

The «logical» structure of the process (conditions of precedence and incompatibility of actions) is given by the «path-task» matrix, which corresponds to the network graph of the process:

$$V = \|v_{ij}\|_{m \times n}, \quad (6)$$

where m is the number of paths on the graph; n is the number of tasks that make up the operation; v_{ij} is a matrix element that takes the value 1 if the j-th task belongs to the i-th path, and 0 otherwise.

If the forces are distributed according to the plan:

$$Y = \langle y_j, j = \overline{1,n} \rangle, \quad (7)$$

where y_j is the number (calculation units are CU) of forces and devices of communication allocated to support the j-th task of communication organization, then the duration of the process paths will be, respectively:

$$T_i = \sum_{j=1}^{n} v_{ij} \cdot \tau_j(y_j) = \sum_{j=1}^{n} v_{ij} \cdot \left(\frac{a_j}{y_j} \right), i = \overline{1,m}. \quad (8)$$

It is necessary on a set of plans $\{\boldsymbol{X}\}$ for the distribution of forces and devices of communication according to the tasks of the process of their application, each of which satisfies the condition for the acceptable duration of the operation:

$$T_i(y) \le TS^{oper}, \quad (9)$$

find the following (optimal) plan for the distribution and use of forces and devices of communication:

$$Y^o = \langle y_j^o, j = \overline{1,n} \rangle, \quad (10)$$

which minimizes the composition of forces and devices of communication (CU).

$$NS(Y^o) = \min_{\{Y\}} NS(Y) = \sum_{j=1}^{n} y_j^o. \quad (11)$$

This is an inverse task that maximizes the overall effectiveness of communication actions in task execution operations:

$$ES^{com}(Y^o) = \frac{WS^{nes}}{NS(Y^o) \cdot TS(Y^o)} =$$
$$= \frac{WS^{nes}}{\min NS \cdot TS^{oper}} = \max ES^{com}. \quad (12)$$

A direct task is on a set of plans $\{Y\}$ for the distribution of forces and devices of communication according to the tasks of the application process, each of which Y satisfies the condition for the available composition of the forces of the group:

$$NS(Y) = \sum_{j=1}^{n} y_j \le NS^{fors}, \quad (13)$$

find the following (optimal) plan for the distribution and use of forces and devices of communication:

$$Y^o = \langle y_j^o, j = \overline{1,n} \rangle, \quad (14)$$

which minimizes the total duration of the communication organization process:

$$TS(Y^o) = \min_{\{Y\}} TS(Y) =$$
$$= \min_{\{Y\}} \{\max_i T_i(Y)\} = \min_{\{Y\}} \left\{ \max_i \sum_{j=1}^{n} v_{ij} \cdot \tau_j(y_j^o) \right\}. \quad (15)$$

This force action plan also maximizes the effectiveness of the distribution and use of forces and devices of communication:

$$ES^{com}(Y^o) = \frac{WS^{nes}}{NS(Y^o) \cdot TS(Y^o)} =$$
$$= \frac{WS^{nes}}{NS^{fors} \cdot \min TS} = \max ES^{com}. \quad (16)$$

5. *Obtaining generalized data for solving direct and inverse problems.*

At this stage of the method, there is a generalization of the direct and reverse tasks of distribution of forces and devices of communication and verification of the fulfillment of requirements in accordance with the purpose of the operation.

3.2. Results of the analysis and discussion of the results. In the course of the research, the authors developed a method for the distribution of forces and devices of communication of groups of troops (forces) in operations.

The proposed method allows:

– to take into account the type of uncertainty regarding the operational situation in the operational space;
– to take into account the number of members of the group (consumers of communication services) of groups of troops (forces) in operations;
– to take into account the duration of the operation while planning measures for the distribution and use of forces and devices of communication;
– to calculate the labor costs necessary to meet the needs of communication services of groups of troops (forces).

The advantages of the research include:

– taking into account the type of uncertainty about the state of the operational situation;
– carrying out a rational distribution of forces and devices of communication among users of communication services;
– simultaneous use of direct and inverse tasks on the distribution of forces and devices of communication among users of communication services. Both problems belong to the class of non-linear programming problems due to the non-linearity of the «duration-cost» function of tasks, paths and the process as a whole. The «inverse» problem of the optimal allocation is the

«basic» one, since the limit and the allowable duration of the operation are always set from above.

The shortcomings of the mentioned research include:
– the need to know the type of uncertainty about the operational situation;
– availability of time to carry out calculations on the distribution of forces and devices of communication of troop groupings (forces) in operations.

It is advisable to use the specified method:
– in planning documents during planning of the deployment and operation of forces and devices of communication;
– in the software, during operational management of the communication system of troop groups.

The direction of further research should be considered the further improvement of the specified method for an objective and complete analysis of the initial situation.

4. Conclusions

In the research, the method for the distribution of forces and devices of communication of troop groupings (forces) in operations was developed.

The novelties of the proposed method are:
– taking into account the type of uncertainty regarding the operational situation in the operational space;
– taking into account the number of members of the group (consumers of communication services) of groups of troops (forces) in operations;
– taking into account the duration of the operation (fighting) while planning measures for the distribution and use of forces and devices of communication;
– calculation of labor costs necessary to meet the needs of communication services of groups of troops (forces).

The specified method is proposed to be implemented:
– in planning documents during the planning of the deployment and operation of forces and devices of communication;
– in software, during operational management of the communication system of troop groups.

Conflict of interests

The authors declare that they have no conflict of interest in relation to this research, including financial, personal, authorship, or any other nature that could affect the research and its results presented in this article.

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Data availability

The manuscript has no associated data.

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✉ ***Oleg Sova,*** *Doctor of Technical Sciences, Senior Researcher, Head of Department of Automated Control Systems, Military Institute of Telecommunications and Information Technologies named after Heroes of Kruty, Kyiv, Ukraine, e-mail: soy_135@ukr.net, ORCID: https://orcid.org/0000-0002-7200-8955*

Yurii Zhuravskyi, *Doctor of Technical Science, Senior Researcher, Head of Department of Electrical Engineering and Electronics, Zhytomyr Military Institute named after S. P. Koroliov, Zhytomyr, Ukraine, ORCID: https://orcid.org/0000-0002-4234-9732*

Andrii Shyshatskyi, *PhD, Senior Researcher, Head of Department of Robotic Systems Research, Research Center for Trophy and Perspective Weapons and Military Equipment, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0001-6731-6390*

Oleksandr Zhuk, *Doctor of Technical Sciences, Associate Professor, Head of Department of Information Security in Telecommunication Systems and Networks, Military Institute of Telecommunications and Information Technologies named after Heroes of Kruty, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-3546-1507*

Taras Hurskyi, *PhD, Associate Professor, Head of the Research Department, Military unit A1906, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0001-7646-853X*

Oleksii Nalapko, *PhD, Senior Researcher, Research Laboratory of Research Automation, Central Scientific Research Institute of Armament and Military Equipment of the Armed Forces of Ukraine, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-3515-2026*

Roman Vozniak, *PhD, Head of Research Laboratory of Information Technology Problems, Institute for Providing Troops (Forces) and Information Technologies, The National University of Defense of Ukraine named after Ivan Chernyakhovskyi, Kyiv, Ukraine, ORCID: http://orcid.org/0000-0002-3789-2837*

Serhiy Hatsenko, *PhD, Deputy Head of Department of Intelligent, The National University of Defense of Ukraine named after Ivan Chernyakhovskyi, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-0957-6458*

Anna Lyashenko, *Researcher, Scientific Center, Military Institute of Telecommunications and Information Technologies named after Heroes of Kruty, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-5318-8663*

Oksana Havryliuk, *Researcher, Scientific Center, Military Institute of Telecommunications and Information Technologies named after Heroes of Kruty, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0001-8694-7251*

✉ *Corresponding author*